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*The Improvement of Tidal Rivers, as exemplified by the Former and Present Condition of the River and Harbour of Glasgow.* By JOHN STRANG, LL.D.

[Read before Section (F), Economic Science and Statistics, of the British Association, at Dublin, on Saturday, 29th August, 1857.]

NOTHING has contributed more to the wonderful development of the manufactures and commerce of Great Britain than the attention which has been devoted during the last hundred years to the improvement of its Tidal Rivers. Many important streams which were formerly altogether impassable, except for mere row-boats, have been rendered navigable for large vessels, while a few paltry villages, which spotted their banks, have been converted into busy towns or mighty cities. Among the many rivers throughout England, Scotland, and Ireland, which, by means of engineering skill and able administration, have become the great highways of trade and commerce, none has made, in so short a period, such gigantic progress in improvement as the Clyde. In the course of less than a century this stream, which at first offered a succession of shallow barriers to any navigation beyond that of a few flat-bottomed barges or lighters, has now become the great outlet from Glasgow to the ocean, bearing on its waters ships of the largest tonnage, and the flags of every nation.

Let us see how and by what means this has been accomplished, and then note some of the effects which have flowed therefrom, not only on the city with which it is closely connected, but on the industries which it has reared on its banks, along with the economic advantages which have thereby accrued to the nation at large.

We need scarcely state that the River Clyde takes its rise among the wastes of the mountains which separate Lanarkshire from Dumfriesshire, about 1,400 feet above the level of the sea, and near to the sources of the Annan and the Tweed; and after running a course of upwards of 100 miles—through successively a pastoral, and picturesque, and a flat and fertile country—empties itself into the sea near Greenock. At about 20 miles from its embouchure stands the city of Glasgow, which, at the middle of last century, was little more than a small town, with a trifling trade, and a population not exceeding 24,000. It has been upon these twenty miles of the river flowing from Glasgow to the sea that the genius of the engineer and the energy of the Clyde Trustees have been exerted; and the result has been the formation of an inland navigation and a stream harbour such as perhaps are not to be met with in Europe.

The area of the country drained into the Clyde above Glasgow is 736 square miles, and the greatest quantity of water noted as flowing down the stream during the greatest flood was found to be about 33,885 cubic feet per second, while in ordinary moderate weather there are only about 600 to 1,000 cubic feet passed per second. The basin of the Clyde, so far as the river is concerned, may be described as a huge accumulation of mud of great depth in former times, overlaid by a bed of sand, occasionally crossed by hard ridges in which there are large boulders, and in one instance by a bed of whinstone rock about 100 yards along the river.

Previous to 1758 the now navigable portion of the Clyde may be said to have been in a state of nature. Its banks were liable to be overflowed during floods; it was fordable both by horses and carriages at many places between Glasgow and the sea, and it was only at high water that even the smallest craft were able to struggle up the stream. Mr. Smeaton, the celebrated engineer, was one of the first who reported on the river Clyde, with a view to its improved navigation; and from that report may be gathered the fact, that in 1755 the ford about two miles below Glasgow was only one foot three inches deep at low water, and three feet eight inches at high water, and that the ordinary neap tides were merely "*sensible*" at the Bridge of Glasgow. His leading proposition to improve the navigation was to increase the height of water by the formation of a dam and lock at Marlinford, which was happily not executed. In 1768 the advice of Mr. Golbourne having been taken, that gentleman suggested that the best and only way to obtain depth was to erect jetties, thereby to contract the bed of the river, and thus to deepen by means of the flood and scour of the stream itself. From a survey made by Mr. James Watt, the well-known improver of the steam-engine, previous to these operations being commenced, it was discovered that several parts of the river, for two miles below Glasgow, had less than two feet of water.

In 1770 an Act of Parliament was procured, by which the members of the City Corporation were appointed trustees, with powers to levy dues;\* and on this Act being obtained a contract was forthwith entered into with Mr. Golbourne for deepening the river, and before the close of 1775 we find that he had erected 117 jetties on both sides of the stream, which, by confining its waters within narrow limits, enabled vessels drawing fully six feet water to come up to the Harbour of Glasgow at the height of the tide. Since that period Mr. John Rennie in 1799, Mr. Thomas Telford in 1806, Mr. Whidbey in 1824, Mr. Charles Atherton in 1833, Mr. David Logan in 1835, Mr. Bald in 1844, Mr. James Walker in 1847, Mr. David Brebner in 1849, and the present resident engineer, Mr. J. F. Ure, in 1854, have each suggested most important improvements which have been successively carried into execution both on the River and Harbour.†

The result of these operations has been, that while, in the beginning of the present century, the depth of the Clyde at Glasgow scarcely exceeded five feet, and the craft arriving at the Harbour scarcely exceeded 30 or 40 tons burden, the average available depth of the Clyde at high water during neap tides was in 1820—9 feet, which admitted vessels drawing  $8\frac{1}{2}$  feet water. In 1840 the depth was increased to 14 feet; and in 1850 the average available depth at high water of neap tides was 14 feet; while at this moment (1857) the average depth at high water neap tides is 18, and at springs 20.

In reviewing the past history of the river Clyde, it will be seen

\* The present Constitution of the River Trust consists of the Lord Provost, 8 Magistrates, the Dean of Guild, Deacon Convener, 16 Councillors, the Chairman of the Chamber of Commerce, 3 Members of the Merchants' House, and 2 Members of Trades' House—in all, 33.

† Mr. James Walker, of London, has for many years been the consulting engineer of the Clyde Trustees.

that the first successful attempt to render it navigable was made by Mr. Golbourne, by introducing jetties to narrow and confine the stream. This was afterwards followed by connecting the ends of these jetties by parallel dykes; the jetty system having attained a depth of about eight feet, whereas in 1824 an additional deepening of three feet was produced by the adoption of the parallel dykes, though it would be wrong altogether to attribute the whole of this improvement to their influence. The fact is, that a part of it was due not only to the truer direction given to the land floods and the current of the ebb and flood, but to the effects of the steamers in deepening the channel. The next improvement was the gradual raising of the half-tide connecting parallel dykes to full-tide dykes, since which time nothing has been done to these except in the upper part of the river, where they have been placed further apart to effect the widening which has since taken place.

Simultaneously with beginning to raise the parallel dykes in 1824, the steam dredging machine was introduced; and not long after the number, speed, and size of the steamers increased, and continued progressively to do so. In 1830 the greatest draught of any vessel arriving at Glasgow was 13 feet, and 284 tons register; in 1835, 14 feet draught, and 321 tons; and in 1839,  $16\frac{1}{2}$  feet draught, and 606 tons. In what proportion to distribute amongst the various promoting causes the rapid enlargement of the river, especially in the latter period, it is impossible, with any close degree of accuracy, to say. Judging, however, from the experience of 1839 to 1854, Mr. Ure, the present resident engineer on the Clyde, seems to think that about as much of the increased capacity of the river is due to the action of the steamboat traffic as to the dredging machine; and assuming that the completion of the parallel dykes attained the same proportional advantages which had been got by forming half-tide dykes between the ends of the jetties, we find that about 18 inches is due to this cause, leaving about  $2\frac{1}{2}$  feet to the combined action of the dredging machine and the steamboat traffic.

In short, the following conclusions may be arrived at.

1st. That the river, in its natural state, was capable only of maintaining a navigation of three feet up to Glasgow at good spring tides.

2d. That by properly directing the natural powers of the river within the best-planned artificial works, it was capable of attaining, by means of full-tide jetties, a depth of eight feet; by connecting these with half-tide parallel walls, a depth of about 10 feet; and thereafter, by raising these half-tide into full-tide walls, an ultimate depth of about  $11\frac{1}{2}$  feet.

3d. That the combined processes of dredging and steam navigation had, prior to 1839, formed an artificial river of the increased depth of 15 feet.

4th. That the combined action of the dykes, dredging machine, and steamboat traffic had, prior to 1854, further deepened the artificial river, so that vessels of 18 feet draught arrived as easily as those of 15 feet in 1839, showing an increase in the depth of the river of about 3 feet in 15 years—a depth which the same causes are steadily increasing, as well as improving the sectional capacity of its channel.

When on this part of the subject it is but fair to state that the plan of improvement suggested by Mr. David Logan was the first that proposes a general enlargement of the navigation, not only in regard to depth, but also as to increase of the width and sectional area, and for the construction of a straighter channel. His report, in fact, forms the foundation on which all the plans for the improvement of the river have since proceeded, the only variation being an increased width, so as to accommodate the greater number and larger and increasing size of vessels passing along the river. It may be here mentioned that, by deepening, widening, and straightening the river, an additional tidal column of water has been brought to Glasgow of about  $6\frac{1}{2}$  feet—the rise of tide being  $6\frac{1}{2}$  feet at neaps and  $8\frac{1}{2}$  feet at springs, while the level of high water between Glasgow and the sea has somewhat risen since 1800, but to an extent not exceeding a foot.

To maintain and increase the depth of this artificial inland navigation there are at present employed six dredging machines—four single and two double—the former with engines from 16 to 24 horse power, and the two latter with a power of 40 horses each. The greatest depth in which the single dredgers can excavate is from 13 to 18 feet, the double dredgers being able to dredge to the depth of from  $22\frac{1}{2}$  to 25 feet. There are also 26 iron and 325 timber punts employed for transporting the dredgings to the shore, and 7 timber punts for transporting stones; while there are two tug steamers, with engines of 40 and 80 horse power each, for towing punts, and a diving bell and apparatus for lifting stones. The quantity of material dredged by these machines during the 12 years from 1844-45 to 1855-56 was 3,320,856 cubic yards; while during the last year alone no less than 505,976 cubic yards have been taken up from the river and harbour. The enlargement of the river by the removal of ground carried away by means of forces proceeding from its own channel, has been estimated at 1,153,385 cubic yards.

With respect to the Harbour of Glasgow, the change has been equally marked during the last fifty years. In 1800 the whole quay was limited to a space not exceeding a few hundred yards, and exhibited no vessel larger than a coal barge or a herring wherry. At this moment the quayage extends to about 4,500 lineal yards, or about  $2\frac{1}{2}$  miles; while hundreds of the largest ships and steamers belonging to the mercantile marine of this and foreign countries are seen ranged three and four deep along its breast. The quays are amply provided with handsome and roomy sheds for goods, and with cranes and other appliances for working a first-rate harbour. Among the 19 cranes, 4 of which are wrought by steam power, there is one lately erected which may be well termed gigantic, being capable of lifting, easily, 60 tons. The Harbour also is connected on its south side by means of the General Terminus Railway with the Caledonian and South-Western Railways, which unites the great coal and iron districts of the country with the Harbour. Ground has also been acquired and an Act obtained for constructing Docks on both sides of the river; and the Trustees only wait a favourable opportunity for carrying their project into effect. The present extent of the Harbour is about 60 acres.

In proof of these river improvements, and as an index to their progress, let us here note the number of vessels which arrived at the Harbour of Glasgow, with their registered tonnage, during the years ending July 1828, 1840, 1850, and 1857 :—

*Glasgow.—Classes of Vessels Entered Inwards—1828-57.—Numbers.*

I.—Not above 300 Tons.								
Year.	Under 40 Tons.	40 to 60.	60 to 80.	80 to 100.	100 to 150.	150 to 200.	200 to 250.	250 to 300.
1828....	2,117	2,847	4,605	1,399	213	20	14	1
1840....	3,256	4,256	3,945	2,975	922	326	171	284
1850....	4,319	2,245	2,894	3,204	733	517	321	128
1857....	5,370	1,932	4,746	2,557	929	890	233	361

  

II.—Above 300 Tons.								
	300 to 350.	350 to 400.	400 to 450.	450 to 500.	500 to 600.	600 to 700.	700 to 1,000.	1,000 and Upwards.
1828....	....	....	....	....	....	....	....	....
1840....	107	118	90	2	4	....	....	....
1850....	213	145	110	36	151	15	16	7
1857....	117	515	68	35	59	27	66	35

The whole tonnage arriving at the Harbour of Glasgow during the same periods was as follows :—

*Glasgow.—Arrivals, 1828-57.*

Years.	Sailing Vessels.		Steam Vessels.		TOTAL.	
	No.	Tonnage.	No.	Tonnage.	Vessels.	Tonnage.
1828....	4,405	214,315	7,100	481,946	11,505	696,261
1840....	5,337	271,942	11,149	894,387	16,486	1,166,329
1850....	5,857	392,033	9,195	873,159	15,052	1,265,192
1857....	5,762	439,409	12,808	1,173,182	17,960	1,612,681

From these tables it appears that the tonnage has increased since 1828 to the present time from 696,261 to 1,612,681, while in 1828 there was not a steamer above 100 tons at the harbour. What a contrast does this exhibit to that of the present, when such vessels as the *Persia*, of 3,600 tons, are seen sailing down the river.

The number of *Arrivals* at the Harbour of Glasgow from June, 1855, to June, 1856, was of Sailing vessels 5,779, and of tonnage 445,976 ; of Steam vessels, 11,804, and tonnage 1,227,120, or a total

of 17,583 vessels, the tonnage of which amounted to 1,673,096. Of the steam vessels which arrived there were 10,579 from Scotland, 213 from England, 887 from Ireland, 29 were from foreign countries, and 96 were built in or near the Harbour.

The number of *Foreign* sailing vessels entering the port during year 1855-56 were 99, of which 43 belonged to the United States; 18 to France, and 13 to Spain and Portugal; 6 to Sweden and Norway; 8 to Germany, and 3 to Naples. The whole vessels employed in the Foreign Trade at Glasgow with cargoes were in 1856: inwards 491, and 141,701 tons; outwards, 918 vessels, and 247,482 tons. The above ships inwards are only those which have not previously landed any part of their cargoes at other ports in their passage, while those that have only brought the balance of their cargoes, and which are numerous, are excluded.

As another proof and result of the improvements on the River Clyde and Harbour of Glasgow, we have only to glance at the amount of Duties levied at the Glasgow Custom House during the following epochs since the year 1796, when the whole duties levied only amounted to 125*l.* 13*s.*

*Glasgow.—Customs Duties Collected—1801-56.*

	£		£
1801 .....	469	1830 .....	59,013
1806 .....	1,323	1835 .....	270,667
1812 .....	3,124	1840 .....	468,974
1815 .....	8,300	1845 .....	551,851
1820 .....	11,000	1850 .....	640,568
1825 .....	41,154	1856 .....	718,835

In examining the above table, it will be seen that since the beginning of the century the Custom House duties have risen from about 470*l.* to about 719,000*l.* It must be remembered, however, that the rise in the Government revenue between 1840 and 1856 gives but an inadequate idea of the increase of business, or of the consumption, seeing that during the course of those years many serious fiscal changes had occurred through Sir Robert Peel's new tariff, calculated to lessen the revenue.

It may now be asked at what cost has all these great River and Harbour improvements been obtained? It appears from the accounts published by the Trustees, that the whole expenditure of the Trust since 1770 to July 1857, has been 2,676,505*l.*, of which 574,708*l.* has been paid for ground acquired for the extension of the Harbour and the widening of the River; 253,963*l.* for dredging and deepening the River; and 658,473*l.* for construction of works on the River and Harbour, and the remainder for interest on money borrowed, management, maintenance, &c., &c.

This may perhaps be regarded as a very large sum; but when we look to the revenue which has been collected by the Clyde Trust during the same period, which has amounted to 1,686,016*l.*, it will appear plain that the undertaking, without any reference to the many contingent advantages gained from the improvements in relation to the city of Glasgow and the country at large, has been highly successful. The following is a *vidimus* of the revenue at different

periods, which, perhaps, more than anything else, marks the financial course which has followed the improvements:—

*Glasgow.—Revenue of Clyde Trust—1771-1857.*

	£		£
In 1771 .....	1,044	In 1821 .....	8,070
1781 .....	1,721	1831 .....	18,932
1791 .....	3,175	1841 .....	49,665
1801 .....	3,400	1851 .....	68,875
1811 .....	4,753	1857 .....	82,797

From the foregoing statement it appears that while one year after the improvements commenced the revenue was only 1,044*l.*, the amount last year drawn by the Clyde Trustees was no less than 82,797*l.* The debt is only about 970,000*l.*, consequently a large portion of what may be called real capital has been paid out of revenue.\*

Although these very large sums have been annually drawn, it is but right to state that the dues, both on hulls and cargo, are by no means high, being only 2*d.* per ton on the vessel, 1*s.* a ton on all kinds of grain and meal, 2*d.* on coal, 7*d.* on iron, and on all other articles 1*s.* 4*d.* per ton. In short, the dues are as low, if not lower, than any other large port in the kingdom.

Let us now, in conclusion, shortly glance at a few of the great and beneficial results which may be mainly attributed to the improvements of the Clyde navigation.

And first as to Glasgow and its neighbourhood. Before these operations were commenced, Glasgow had little or no trade from its Port, whereas in 1854 the aggregate value of exports from its Harbour was 4,905,557; and even since that year these have greatly increased. Previous to 1801 the registered ships belonging to Glasgow were *nil*;—in 1856 they amounted to 563, with a tonnage of 204,331.

Formerly there were no ships built on the river; now there are no fewer than 30 large shipbuilding yards and several extensive marine engine manufactories established on its banks, which, in 1853-54, constructed no less than 266 vessels, having an aggregate tonnage of 168,000 tons, for which, also, marine engines were made of 29,000 horse power. The average of these vessels were 630 tons each, and involved the enormous cost of nearly five millions sterling. Previous to the commencement of the river improvements, the population of Glasgow was scarcely 24,000, now it contains 420,000 inhabitants; while its annual rental, which in 1750 was only a few thousands, was last year no less than 1,319,720*l.* Within a few years there were no slip docks, where vessels could be examined and repaired; now there are three, on which several ships are constantly seen placed. As yet there is no public graving dock, but ere a few

* The ordinary annual expenditure ending July, 1857, was.....	£ 75,942
Leaving a surplus revenue of .....	7,305
The total expenditure under the head of "New Works and Improvements," amounted to .....	73,813
Surplus revenue .....	7,305
	<hr/> 66,508



months are passed, the private enterprise of Messrs. Tod & M'Gregor will have finished a dock 450 feet long, with gates 55 feet wide.

Formerly the only passenger communication with the coast was by what were called *Fly-Boats*, whose flight, however, was sometimes as slow as to require two days to go from Glasgow to Greenock; now, hosts of steamers are transporting the population up and down the river at the rate of twelve miles an hour; and as a curious illustration of the facilities now offered for migration, it may be mentioned that on the last holiday Friday of July, no fewer than 134 steamers passed up and down the Clyde, the greatest number of which were laden with crowds of passengers.

The improvements on the Clyde have given a most decided impulse to the opening up and working of the rich fields of Minerals by which Glasgow is surrounded, and which produced in 1855 from Coal and Iron alone nearly 4,900,000*l.*, and gave employment to 33,912 persons, who received for their labour wages to the amount of 1,975,917*l.*

And now, secondly, in a national point of view, these improvements have proved most beneficial.

Take as examples the following:—In 1796 the Customs duties levied at Glasgow were only 125*l.*, whereas last year they amounted to 718,835*l.* In 1781 the revenue of the Glasgow Post Office was only 4,341*l.*; in 1856, with a penny postage, it reached, including the postage stamps sold at Inland Revenue Office, 64,958*l.* In one word, while the taxes paid into the public treasury through the city of Glasgow before the Clyde improvements commenced were comparatively speaking nothing, the various Crown revenues collected there last year, reached no less a sum than 2,800,000*l.*, or about one-twenty-fifth part of the whole revenue of the country.

If such be a tolerably correct picture of the past and present of the River Clyde and Harbour of Glasgow, and of the beneficial and economic results which have attended the opening up of the navigation of that river, it is but justice to say that the improvements in question have all been accomplished by local means and local administration. No Governmental assistance has been ever asked for the advancement of this great national work; and it is to be feared, if any had been got, that the benumbing influence of centralisation and red-tapeism accompanying it, would have utterly paralysed the undertaking. It is to the individual interest which each and all of the successive bodies of Trustees have felt in the progress and success of the work, and it is to their spirit of enterprise as merchants, and their able administration as traders, that the country owes, in fact, the navigation of the Clyde.

It is another proof, if any were wanting, of the value of local government, and the advantages to be derived from our municipal institutions; and it may well teach a lesson to all communities similarly situated to that of Glasgow, to trust to their own energies, and to resist as strenuously as possible the late insidious endeavours of departments of Government in their attempts to control local management and administration.

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